

Electrical Identification of the Recurrent Laryngeal Nerve: *

I. Response of the Canine Larynx to Electrical Stimulation of the Recurrent Laryngeal Nerve

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EXCELLENT papers^{1, 3} and at least one book⁵ have been written on the recurrent laryngeal nerve in operations on the thyroid gland, and the literature has been reviewed. In large series of operations on the thyroid, there is a small but significant incidence of injury to the nerve and resultant impairment of laryngeal function is serious. Knowledge of the anatomy and careful surgical technic will keep the incidence of injury low, but certain anatomic features make the nerve vulnerable. These are:

1. An anomalous nerve which, instead of looping around the subclavian artery, goes directly from the vagus to the larynx

2. Extralaryngeal branches in the region of the thyroid

3. Displacement of the nerve by pathologic processes in the thyroid gland.

There is need for a means to determine whether a filamentous structure found at operation is or is not the recurrent laryngeal nerve or a branch thereof. The need is particularly strong in patients who have large goiters and in whom the nerve can be displaced from its normal course. Hawe and Lothian² point out that variations in the cervical course of the nerve are the rule rather than the exception. Surgical opinion is divided on whether it is practical to dissect out the nerve in order to preserve it. Opinion is also divided on

whether such dissection exposes the nerve to undue trauma. Hawe and Lothian, in their series of more than 1,000 operations in which the nerve was exposed, demonstrated the feasibility of such an undertaking.

In other anatomic regions such as the parotid the surgeon can utilize an electrical stimulator to identify the facial nerve and its fine branches. In this situation, contraction of facial muscles in response to stimulation provides identification. In the case of the recurrent laryngeal nerve there is no such convenient indicator of response stimulation. Experiments reported in this paper are efforts to develop a sensor which will indicate when the recurrent laryngeal nerve is stimulated in the course of operations on the neck. Specifically, the question is whether pressure changes within the larynx, resulting from recurrent laryngeal nerve stimulation, are of sufficient magnitude to be detected by a balloon placed within the larynx and connected to a pressure-recording system. Related studies have been done by Murtagh and Campbell.⁴

Materials and Methods

Acute experiments were carried out on seven dogs anesthetized with pentobarbital sodium. The superior and recurrent laryngeal nerves were exposed in the neck and stimulating electrodes applied to the in-

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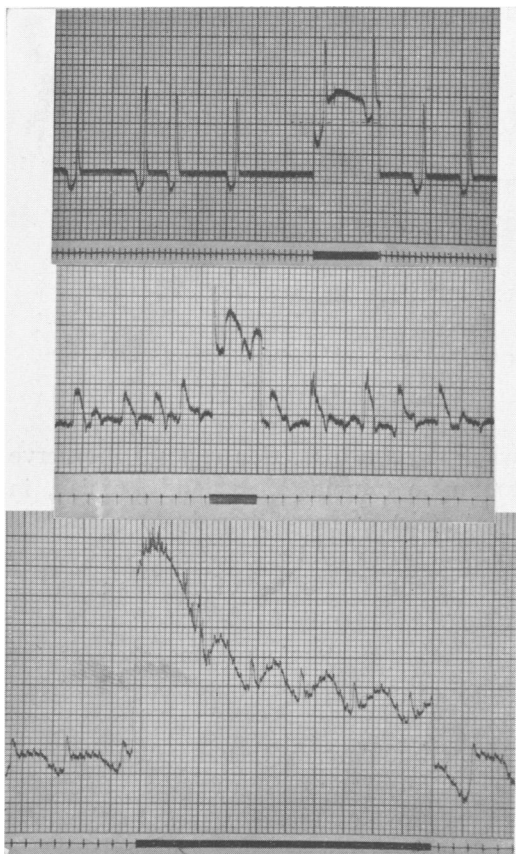


FIG. 1. (Top.) Experiment 2. Pressure responses from endolaryngeal balloon upon stimulation of left recurrent laryngeal nerve (black signal). Time lines—seconds. Pressure calibration: 10 small vertical squares on chart = 2 mm. Hg.

FIG. 2. (Middle.) Experiment 6. Pressure response from endolaryngeal balloon during stimulation (black signal) of left recurrent laryngeal nerve. Time lines—seconds. Pressure calibration: 10 small vertical squares on chart = 1 mm. Hg.

FIG. 3. Experiment 4. Pressure response from endolaryngeal balloon during stimulation (black signal on bottom line) of left recurrent laryngeal nerve. Time line—seconds. Pressure calibration: 10 small vertical squares on chart = 1 mm. Hg.

tact nerves. An endotracheal tube was placed in position, carrying a 3-inch Foregger anesthesia cuff positioned so that the upper end of this balloon lay between the vocal cords. The inflation tube leading from the balloon was connected to a Sanborn direct-writing pressure recorder. After base-line recordings of respiratory pressure changes in the balloon, the nerves

were electrically stimulated and pressure changes recorded. Recordings were made under varying degrees of inflation of the balloon. The electrical stimulator was set at the lowest voltage level which would produce visible response when applied to exposed strap muscles. Stimulation of the nerve was unipolar, with the indifferent electrode attached to the skin.

Results

The pressure recording apparatus connected to the endolaryngeal balloon produces a clear record of respiration which is partly a function of gas flow in the larynx and partly a function of expansion and contraction of the larynx during respiration. The clarity of this spirogram is related to the degree of inflation of the balloon. A balloon equilibrated to atmospheric pressure or one containing 5 to 10 ml. of air was the most sensitive indicator of intralaryngeal pressure changes.

In all experiments stimulation of the recurrent laryngeal nerve caused a specific change in the spirogram. This change consisted of a rise in the baseline coinciding with duration of the electrical stimulation. Magnitude of the rise varied from 1 to 4 mm. Hg, which is two to seven times that of the normal expiratory spike (Fig. 1-3).

Stimulation of both recurrent laryngeal nerves simultaneously produced higher rises in pressure than stimulation of either nerve alone.

In one very sensitive preparation it was possible to demonstrate with higher voltage stimulation a pressure rise (cord adduction) whereas lower voltage stimulation produces a pressure fall (cord abduction).

As a control, stimulation of strap muscles and esophagus was carried out. These contractions did not cause consistent changes in the balloon laryngospirogram. Stimulation of hypoglossal nerve caused a response clearly different from the specific

recurrent laryngeal nerve effect. Vagal stimulation resulted in pressure changes similar to those from stimulation of the recurrent laryngeal nerve.

Stimulation of the superior laryngeal nerve consistently produced pressure changes which were more variable than from recurrent laryngeal nerve stimulation. In some experiments changes were similar to those of recurrent laryngeal nerve stimulation although of lesser magnitude. In other experiments superior laryngeal nerve stimulation caused a pressure drop (Fig. 4).

Discussion

The experiments indicate that in the dog a pressure recording from a balloon in the larynx (endolaryngeal balloon spirometry) will consistently show recognizable changes upon electrical stimulation of the recurrent laryngeal nerve. This provides a dependable method for electrical identification of this nerve. Care is necessary in adjustment of the degree of inflation of the balloon.

In the instance of the superior laryngeal nerve, pressure changes on stimulation were more variable but definite enough to permit identification.

If such a method can be extended to the human, the surgeon will have a dependable means to recognize the recurrent laryngeal nerve and to determine whether any extralaryngeal branches of the nerve carry motor fibers to laryngeal muscles. It would not be necessary to use such a technic in all thyroid operations, but only when the size and location of the gland increase the risk of inadvertent recurrent laryngeal nerve injury.

Clinical evaluation of the procedure is in progress in human thyroid operations. In the first two patients studied, the endolaryngeal balloon pressure recording clearly signalled when the recurrent laryngeal nerve was stimulated (Fig. 5, 6). More patients must be studied before the method can be recommended for clinical use. If

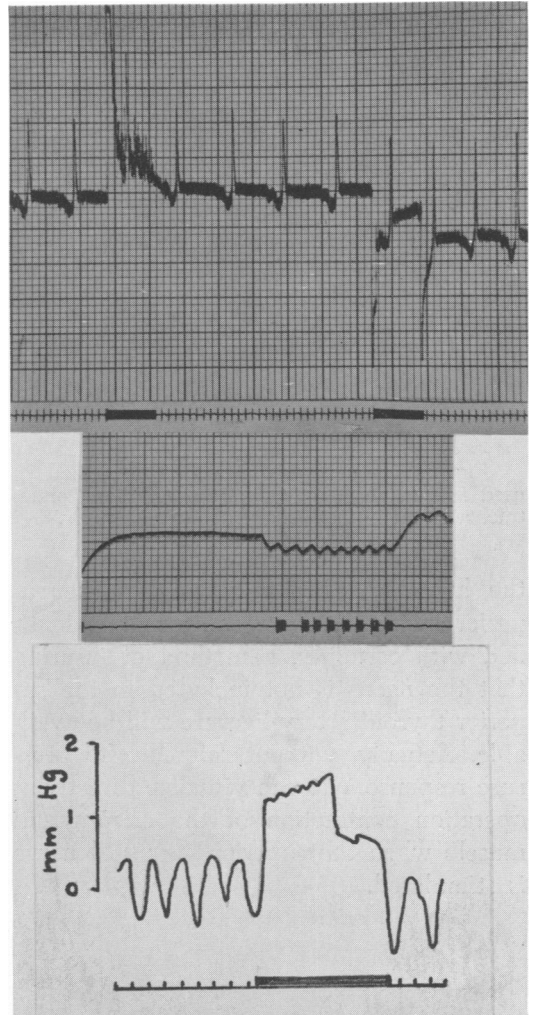


FIG. 4. Experiment 6. Pressure response from endolaryngeal balloon to stimulation of left recurrent laryngeal nerve (1st black signal on bottom line) and then to stimulation of left superior laryngeal nerve (2nd black signal). Time lines—seconds. Pressure calibration: 10 small vertical squares on chart = 1 mm. Hg.

FIG. 5. First attempt to obtain recording from a human thyroidectomy. Pressure response in endolaryngeal balloon shows pressure drops, probably representing cord abduction, during stimulation (black marks on bottom line) of left recurrent laryngeal nerve.

FIG. 6. Tracing of recording in a human subject during radical neck dissection. Pressure response in endolaryngeal balloon shows rise on stimulation (black bar on time line) of right recurrent laryngeal nerve. Time lines—seconds.

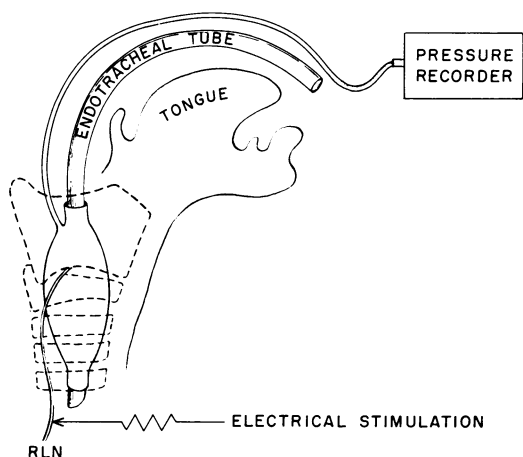


FIG. 7. Diagram of experimental method as used in dog and human. Part of the long endotracheal balloon lies between the vocal cords.

the human studies indicate that the superior laryngeal nerve can also be identified with certainty, a method of insuring that the nerve is not included in the superior thyroid artery ligature will be available. Actually, without reference to pressure response, one can visualize directly at operation contraction of the cricothyroid muscle when the superior laryngeal nerve is stimulated.

Summary

The need for certain identification of the recurrent laryngeal nerve in operations on the thyroid is unquestioned. The nerve is also at risk in other operations such as for cervical esophageal diverticulum or for parathyroid disorders. Limitations of gross anatomic recognition are recognized. A method is described for identification of the recurrent laryngeal nerve in the dog by recording pressure changes in the larynx while the nerve is electrically stimulated. The method provided consistent results in a series of seven animals. It is possible also by the same method to identify the superior laryngeal nerve. Evaluation in man is in progress.

References

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